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ABSTRACT

Presented are various activities and projects intended to help Boy Scouts earn a merit badge in oceanography. Each project and/or activity is related to a requirement (objective) found in a list at the beginning of the booklet. Topic areas and/or related activities and projects include: (1) nature of oceanography (naming oceanography branches, describing ways man is dependent on oceans); (2) effect of oceans on weather and climate; (3) ocean waves; (4) drawing cross-section of underwater topography; (5) chemistry of the seas (listing and describing main salts, gases, and foods found in sea water, and explaining the importance of Dittmar's principle); (6) marine biology, focusing on phytoplankton, zooplankton, nekton, and benthos; (7) plankton collection (making plankton net, making models of volcanic island, making models showing inshore sediment movement, measuring water temperature, and making a wave generator); and (8) oceanographic record-keeping and reporting. Instructions and materials needed for projects and activities are provided when appropriate. Lists of books, hydrographic office publications on oceanography, and glossary of oceanographic terms are included. Activities and projects can be completed whether or not individuals live in coastal areas. (JN)

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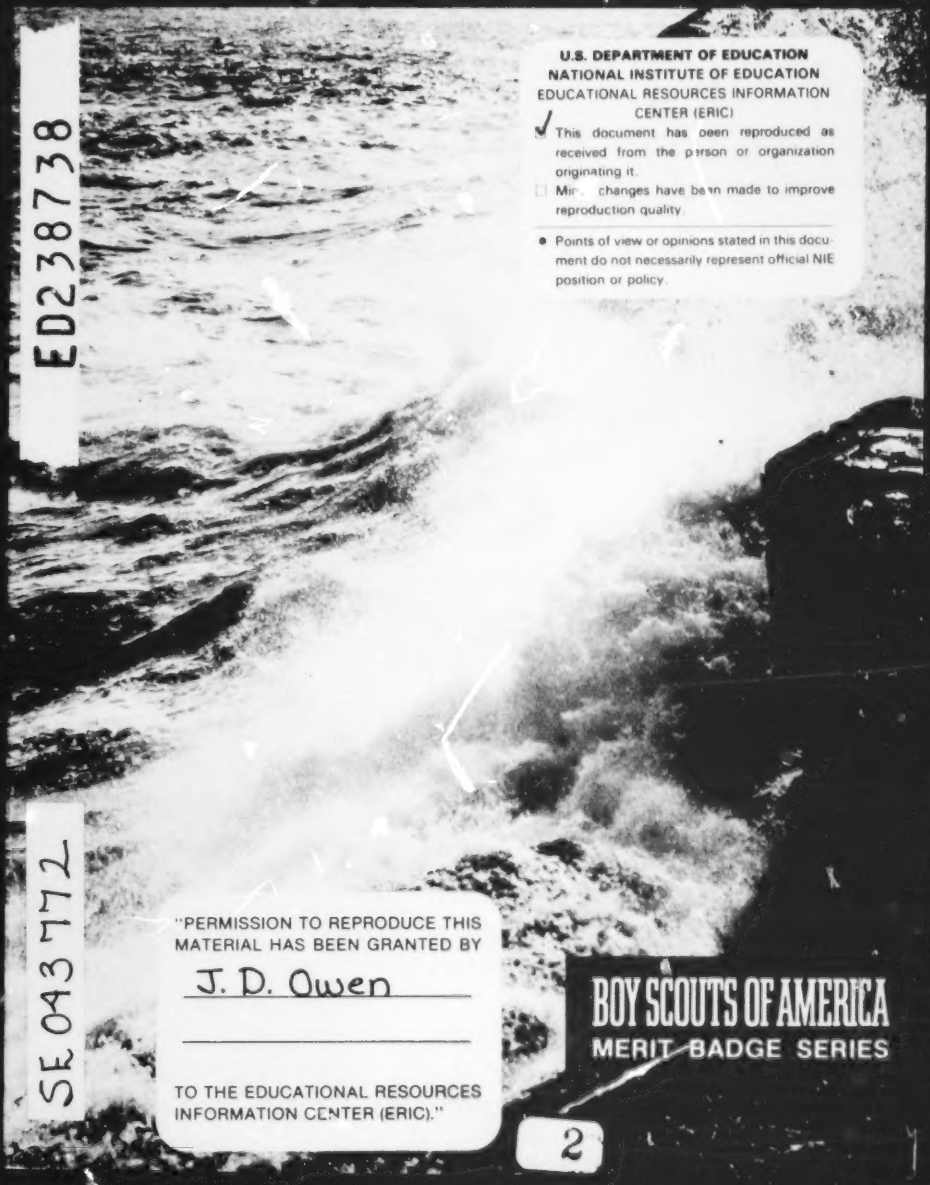

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BOY SCOUTS OF AMERICA
MERIT BADGE SERIES

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The secret to successfully earning a merit badge is for you to use both the pamphlet and the suggestions of your counselor.

Your counselor can be as important to you as a coach is to an athlete. Use all of the resources your counselor can make available to you. This may be the best chance you will have to learn about this particular subject. Make it count.

If you or your counselor feels that any information in this pamphlet is incorrect, please let us know. Please state your source of information.

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Send comments along with a brief statement about yourself to:
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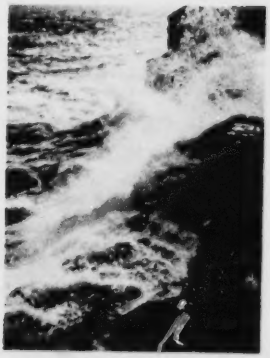
OCEANOGRAPHY



BOY SCOUTS OF AMERICA
IRVING, TEXAS

**1981 Printing of the
1965 Edition**

1. Name five branches of oceanography. Describe at least five ways that man is becoming more dependent upon knowing about the oceans.
2. Describe the effects of the oceans. Include the effect of currents on the weather and climate. Point out how air and ocean currents are alike and different.
3. Tell how ocean waves are described. Point out the differences between the storm surge, tsunami, tidal wave, and tidal bore. Tell the difference between sea, swell, and surf. Explain how breakers are formed.
4. Draw a cross section of underwater topography. Show what is meant by:
   a. Continental shelf
   b. Continental slope
   c. Abyssal plains
   Name and put on your drawing the following: seamount, guyot, deep, rift valley, canyon, and trench. Compare the depths in the oceans with the heights of mountains.
5. List the main salts, gases, and foods in sea water. Describe the importance of these to life in the sea. What is meant by Dittmar's principle? Why is it important?
6. Tell the meaning of phytoplankton, zooplankton,

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nekton, and benthos. Describe the importance of phytoplankton as a main producer of living things. Tell the place and importance of plankton in the food chain.

7. Do one of the following:
   a. *Make a plankton net. Tow the net by a dock, wade with it, hold it in a current, or tow it from a rowboat. Do this for about 20 minutes. Save the sample. Examine it under a microscope or high-power glass. Identify the three most common types of plankton in the sample.
   b. Make a series of models (clay or plaster and wood) of a volcanic island. Show the growth of an atoll from a fringing reef through a barrier reef. Describe the Darwinian theory of coral reef formation.
   c. *Measure the water temperature 1 foot below the surface of a body of water four times daily (8 a.m., 12 noon, 4 and 8 p.m.) for 6 straight days. Measure the air temperature. Note the cloud cover and roughness of the water. Show your findings on a graph. Tell how the water temperature changes with air temperature.
   d. Make a model showing the inshore sediment movement by littoral currents, tidal movement, and wave action. Include such things as high and low waterlines, low tide terrace, cusps, beach scarp, and berm. Show how the offshore bars are built up and torn down.
   e. Make a wave generator. Show reflection and refraction of waves. Show how groins, jetties, and breakwaters affect these patterns.

8. Do one of the following:
   a. Write a 500-word report on any good book about oceanography. (Before reading have your counselor approve it.)
   b. Visit one of the following. Write a 500-word report about your visit: (1) an oceanographic research ship or (2) an oceanographic institute.
   c. Explain to your troop in a 5-minute prepared speech "Why Oceanography Is Important" or "Jobs in Oceanography." (Before making it, show your speech outline to your counselor.)

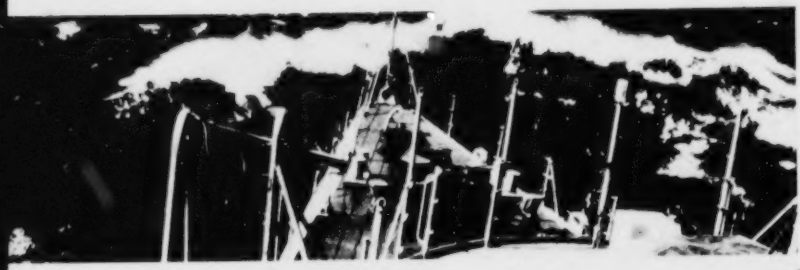
* May be done in lakes or streams.

CONTENTS

What Is Oceanography? 2
How the Oceans Affect Climate and Weather 6
Waves 10
Marine Topography 14
Chemistry of the Seas 17
Marine Biology 22
Plankton Collection 26
Coral Reefs and Islands 28
Water Testing 30
Beach Characteristics 32
Wave Testing 36
Oceanography Reporting
Books About Oceanography 41

Old King Neptune's "golden trident" on your merit badge sash will mean that you have had a sort of baptism into the wonderful world of oceanography. Once you've been doused by old Nep, you will not want to stop learning about his domain under the waves.

Don't be discouraged from trying for Oceanography merit badge because you live far from the sea. The requirements are arranged so that you can earn the badge with as much pleasure as someone living on the coast. Remember, many of our outstanding naval officers as well as some of our most prominent oceanographers came from inland.

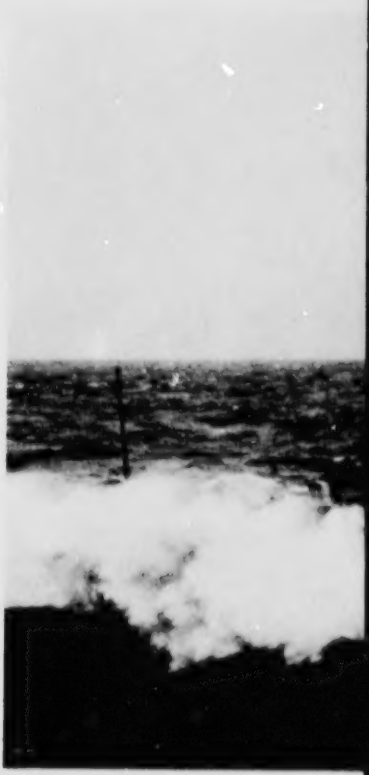


What Is Oceanography?

1. Name five branches of oceanography. Describe at least five ways that man is becoming more dependent upon knowing about the oceans.

There are so many different sciences involved in oceanography that it has something of interest for everyone. Do you like physics, biology, chemistry, geology? They are the main sciences of oceanography, but many other skills and sub-divisions of these four are involved. Photographers, optical experts, biochemists, bacteriologists, zoologists, acoustics experts, and many others are active in the research, plus dozens of technical people in other fields.

So, the main branches of oceanography are physical, biological, chemical, and geological. Another very important one is meteorological, because the oceans have so great an effect on the weather.



Importance of Oceanography

The earliest interest in the oceans was as a source of food. As soon as man discovered that he could build and use boats successfully, the seas became a high-

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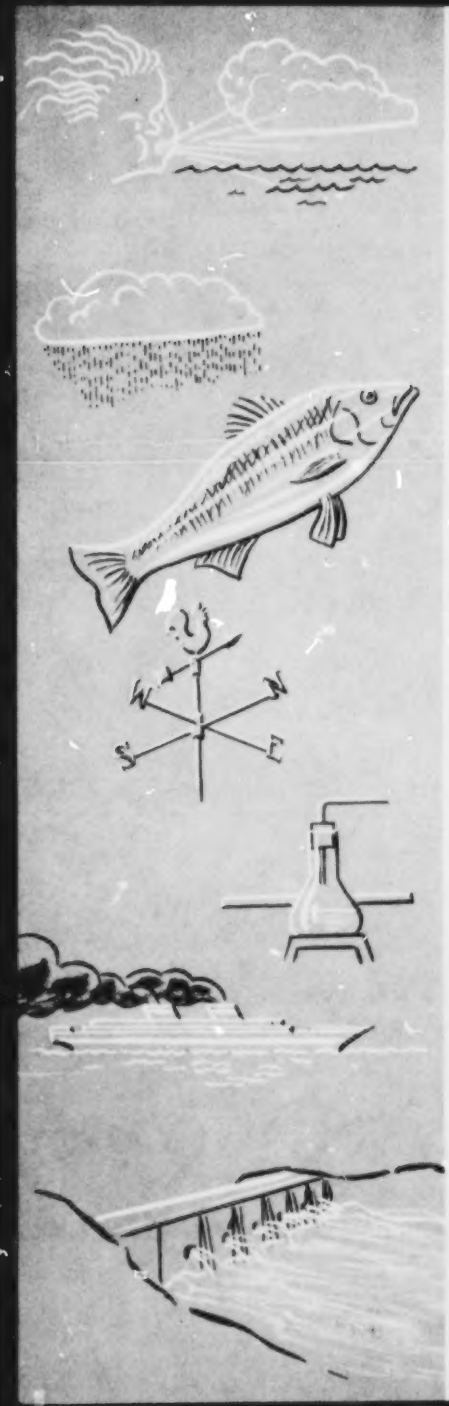


way to far places – a very dangerous highway, but one filled with adventure and exploration.

These two interests led to the first scientific study of the oceans. When nations began to be dependent on the fishing industry, any change in the sources of fish demanded investigation. For instance, a bad fishing season brought hunger and poverty in parts of countries like Norway, Denmark, Sweden, Germany, or England. The people wanted to know where the fish had gone and why, so boats were sent out to try to locate new fishing grounds and to search for causes of the shortage.

When several nations living close together were faced with problems about fishing areas or short supplies of fish, they would cooperate in trying to solve their problems, and some joint investigations began.

Navigation problems also helped to start oceanographic studies. Ships were always dependent on knowledge of the winds, weather, currents, shoals, and so forth; and they would not only share their knowledge as best they could, but they would record unusual happenings about these things in their ship's logbooks. Lt. Matthew Maury, of the U.S. Navy, was one of the first to publish a summary of information from such logbooks, so that mariners could study this information and use it to navi-

gate more safely.

Food and navigation aids are still two of the most important reasons for oceanographic research. With our population expanding so fast, millions of people are finding it hard to get enough food to exist. The future would look almost hopeless if it were not for increased food resources oceanographers are discovering in the oceans. Even the tiny plankton that you will learn about in this pamphlet play a vital part in supplying human food.

Navigation is still filled with adventure; but a worldwide network of information—aided by wonderful electronic instruments and oceanographic research in waves, tides, currents, pressures, and ocean topography – makes the operation of ships much more dependable.

During World War II and since that time, a greater expansion of oceanography has taken place than in all previous history. The operation of submarines during the war demanded a lot more knowledge about undersea conditions. Later, when nuclear subs began to make long underwater trips and deeper dives, the commanders had to have more accurate information about currents, temperatures, pressures, ice, bottom topography, and other factors that led our government to put money and manpower into oceanographic research. In fact, the U.S. Government still pays 90 percent of the costs of all research by our oceanographers.

One of the greatest needs in the world today is a freshwater supply beyond rainfall supplies; and this is most true in countries like Israel, Egypt, Arabia, and other arid areas. Research in this field has made great progress, and some of our newer desalting plants that make fresh water from the sea are able to do this at a cost of $1 per thousand gallons or less.

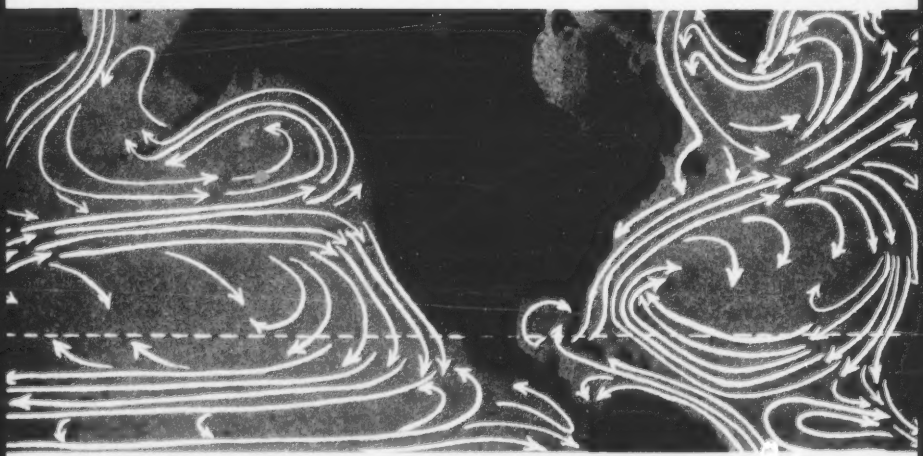
The chemicals and metals found in land areas are being used at a fantastic rate, and someday they are likely to be exhausted. Oceanographers have discovered ways of recovering almost unlimited supplies of many important chemicals in the seawater itself and from the bottom sediments below.

Hydroelectric power generated by tides and currents was only a dream a few years ago, but it is now becoming reality. In one area, huge dams are being built across bays and inlets where tides rise and fall many feet each day. When the tide moves in, it will flow through turbines in one direction generating power, and then as it moves out again the same result will be achieved. And for the future, nuclear power—using hydrogen from seawater—is a possibility.

How the Oceans Affect Climate and Weather

2. Describe the effects of the oceans. Include the effect of currents on the weather and climate. Point out how air and ocean currents are alike and different.

The oceans cover 70.8 percent of the surface of the earth. The Atlantic covers 16.2 percent; the



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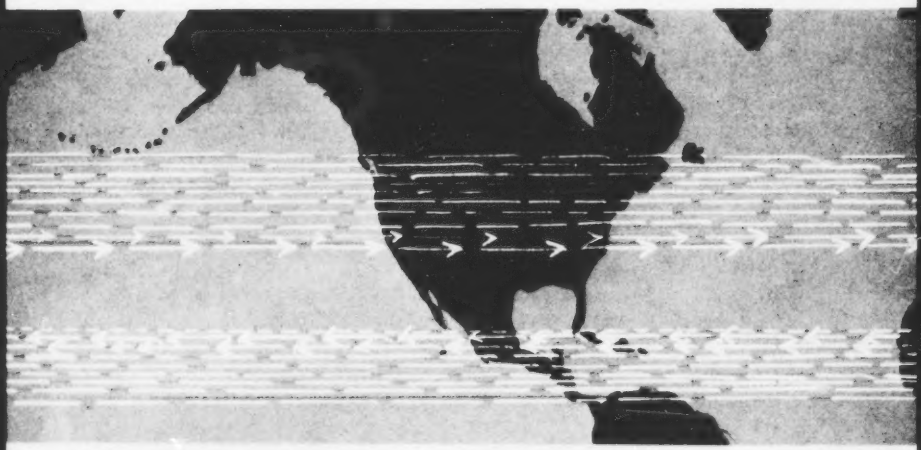
Pacific, 32.4 percent (and this is more than all the land area of the earth); the Indian Ocean, 14.4 percent; and the other seas and oceans (of which the Arctic is the largest), 7.8 percent.

You might expect that such a huge amount of water would have important effects on the land areas, and you would be right. We all know that the air in which we live is in motion. This movement often takes unpredictable turns. But certain patterns like the directions of prevailing winds show that there is some order to this movement.

The oceans are moving in similar ways. The movements of the atmosphere (winds) and oceans (currents) are linked to each other and are often quite similar.

Notice how the ocean currents shown on page 6 follow the direction of the westerly and trade wind belts on page 7.

The continents act as barriers to flow and have an effect on many currents. Where there is little or no barrier, the wind drives the currents in a fairly simple pattern. The Gulf Stream, the popular ocean highway that was first described by Benjamin Franklin, is affected by the barrier of our East Coast. Because it is a warm current, the Gulf Stream has a great influence on the climate of each country in its path. For instance, Bermuda, not



too far south of New York, has a tropical climate; and Great Britain, lying far north of New York City (the latitude is about the same as Labrador), is much warmer on the average than New York.

Likewise, the ocean currents of the Pacific that wash our western shores affect the climate of Washington, Oregon, and California, keeping them cooler in summer and warmer in winter than states inland. They also bring abundant rainfall to the western slopes, particularly in the winter season.

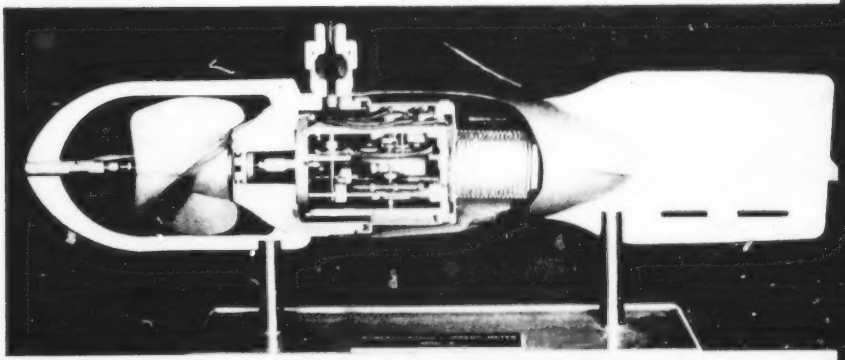
In the area of the Atlantic Ocean where the water picks up the terrific heat of the sun from March to September, the great hurricanes are spawned that move generally northeastward to bring us fall and spring rains (and plenty of wind). These winds get their heat from the warm water underneath them and not directly from the sun.

You might compare our great water-air circulation system with your own heating or air-conditioning system at home that circulates warm or cool air.

There are other ocean currents that are not wind currents. If you have earned your Weather merit badge, you will know that air movements are often caused when denser cool air wedges its way under lighter, warmer air. This type of movement also happens in the oceans as surface water is cooled and sinks to the bottom, forcing warmer water to move upward and away from it.

You can test this kind of movement in your own bathtub by running cold water into a tub of warm water. You will find that the cold water flows straight down and along the bottom, and you have to stir it up to cool off the hot surface water.

Other currents are caused in the oceans when evaporation or ice formation removes fresh



water from the surface, making the remaining water more salty. This stronger saline water becomes heavier than the water under it and sinks to a lower level, causing circulation.

All these currents have an effect on the atmosphere above them and consequently on land areas nearby. There are other coastal currents generated by tides, winds, and density; and these contribute to air circulation (sea breezes or local storms).

Nearly all oceanographic research is conducted from ships equipped to measure and chart many different things about the seas. Typical instruments for measuring current characteristics are the Ekman and Roberts current meters, shown above. Some of these vessels are owned by the U.S. Navy, U.S. Coast Guard, and U.S. Coast and Geodetic Survey. Some are owned by educational institutions and some by state or private organizations.

Our fleet of oceanographic vessels is being rapidly expanded.

The chief differences between air and water circulation are the differences in speed and temperature. Air, being much lighter, moves much faster and changes direction more quickly. It also ranges from far below zero to about 125 degrees F., while ocean water varies from freezing (about 28 degrees) to about 90 degrees. Air temperatures also change much more quickly than water temperatures. These differences contribute greatly to weather changes in coastal areas.

The formation and melting of ice has a great effect upon ocean currents and temperatures as well as ocean levels. A great deal of research is conducted in polar areas to find out what these effects are and how to take advantage of them.

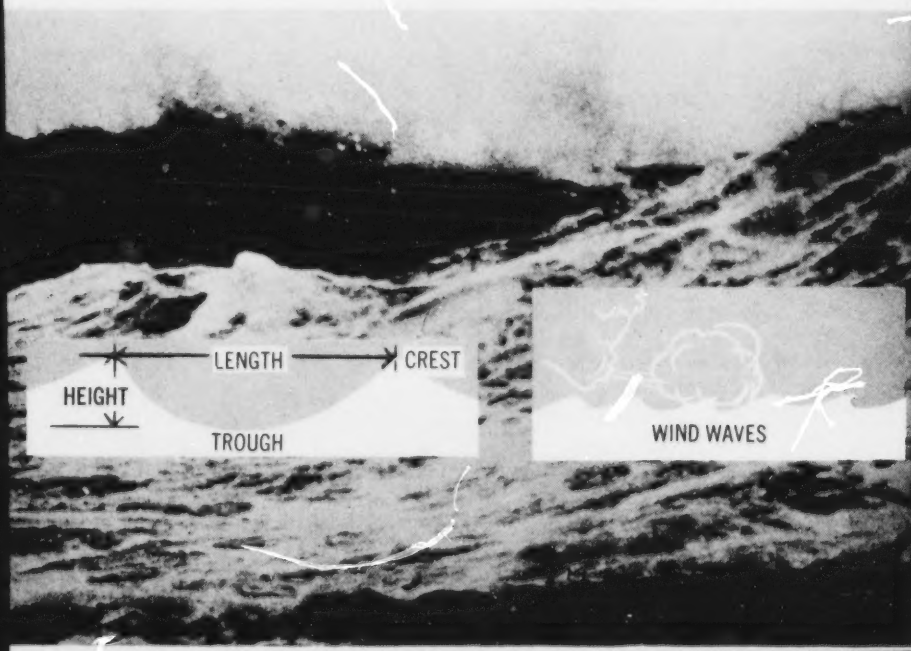
Waves

3. Tell how ocean waves are described. Point out the differences between the storm surge, tsunami, tidal wave, and tidal bore. Tell the difference between sea, swell, and surf. Explain how breakers are formed.

Waves are primarily produced by the wind pushing on the surface of the sea. As the wind raises small elevations on the surface of a water body, these elevations allow the wind more pushing surface and allow it to raise the waves higher and higher. As the wind velocity increases the wave height increases, particularly if the waves have been exposed to the wind over a long distance and a long period of time.

Wave Characteristics

A wave is described by its *length* – the distance from crest to crest; its *height* – the vertical distance from trough to crest; its *period* – the time between two successive crests; and its *velocity* – the speed with which it travels.



Wind Waves

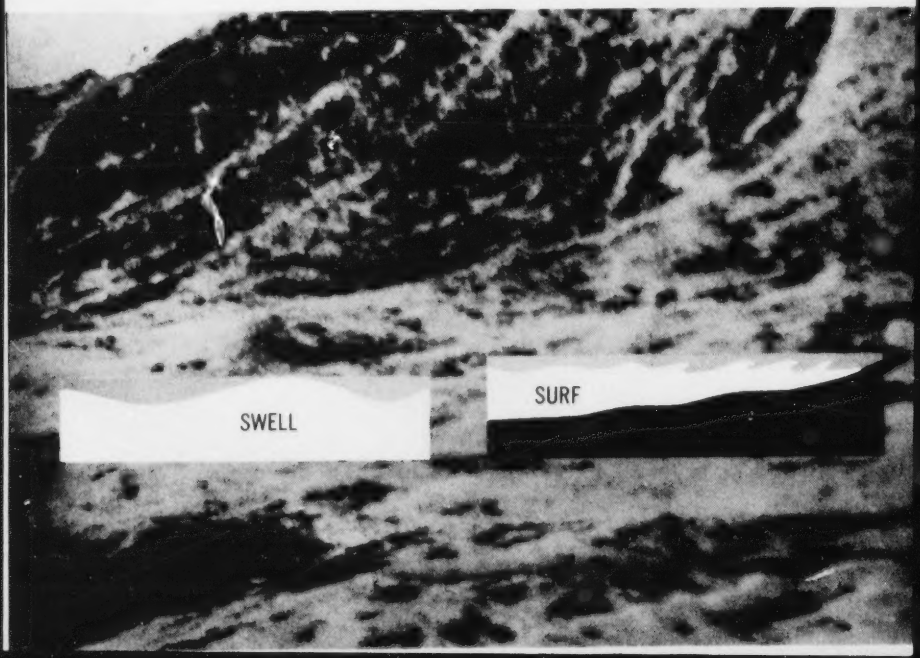
Watching a passing *cat's-paw* as it ruffles the surface of a calm sea, you can see the first stage in the formation of waves. As the wind grows stronger, the ruffles grow into ripples, and the ripples grow into waves. Waves that are still growing under the force of the wind are known as *seas* or *wind waves*. The height and length are determined by:

- the fetch or distance over which the wind is blowing.
- the average wind velocity over the fetch.
- the length of time the wind has been blowing.

In general, wind waves travel in the same direction as the wind that formed them. Sometimes, if the waves are still in the process of formation, the sea will be choppy and difficult to describe. However, as the waves grow, they form themselves into a regular series of crests and troughs at right angles to the wind direction. Their length varies from about 12 to 35 times their height.

Swell

When wind-raised waves travel out of a stormy or windy area, they advance as *swell* and their form undergoes a change. Their height decreases as they advance, their crests become rounded, and their surface becomes smooth. They have none of the characteristics of wind-driven waves.



Often you will find both sea and swell or two or more systems of swells present in the same area. Sometimes a system of wind waves, traveling in the same direction on top of a long low swell, will almost obscure the swell. However, the swell can usually be felt in the roll of a heavy ship.

When two systems of waves cross each other at a considerable angle they form a cross sea. In place of long continuous crests, the wave systems meet to form a very irregular surface of unrelated short-crested peaks and hollows.

Surf

As swell travels across the ocean away from the storm area that generated it, it grows flatter and longer. The waves lose roughly one-third of their height each time they travel a distance in miles equal to their length in feet. Their apparent period, wave length, and velocity increase. The waves are further flattened by an opposing wind.

Eventually the waves, growing flatter and longer, reach shallow water. Here the bottom restricts the motion of the water particles, and the wave is slowed down. The wave train is telescoped together, the wave length decreases, and the wave height increases. When the height-length ratio reaches a critical point, the crest topples forward, and the waves break and become surf.

Waves can also steepen to the breaking point in deep water by meeting a strong opposing current in a short, narrow channel. The action of strong gusts of wind will also add energy rapidly to the wave form causing it to steepen and become unstable. Such short-crested waves breaking in deep water are the familiar whitecaps. Whitecaps occur only with wind velocities greater than 12 knots.

Other Types of Waves

Tsunamis (soon-am-ees) are ocean waves produced by sudden, large-scale motion of a portion of the ocean floor or the shore, as by volcanic eruption or earthquake. Either a tsunami or a storm wave that overflows the land is popularly called a *tidal wave*, although it bears no relation to the tide.

Tsunamis usually occur in a series, gradually increasing in height until a maximum is reached between about the third and eighth wave. Waves may continue to form for several hours or even for days.

In deep water the wave height of a tsunami is probably never greater than 2 or 3 feet. Since its wave crests are usually considerably more than 100 miles apart, it is not conspicuous at sea. In the Pacific where most tsunamis occur, the wave period

varies between 15 and 60 minutes, and the speed in deep water is more than 400 knots.

On April 1, 1946, seismic sea waves, originating near the Aleutian Islands, spread over the entire Pacific. Scotch Cap Light on Unimak Island, 57 feet above sea level, was completely destroyed. Traveling at a speed of 490 miles an hour, the waves reached the Hawaiian Islands in 4 hours and 34 minutes, arriving as waves 50 feet high and leaving a toll of 173 dead and $25 million in damage.

A tsunami warning system has been set up to alert areas in the path of such waves in the future to help avoid such loss of life.

Storm Waves or Surges

Under normal conditions, the regular tide that is caused by the moon's attraction successfully masks the effects of storms except for the surf pounding on the shores. However, in extremely severe storms or tropical cyclones (hurricanes or typhoons), the sea may be pushed toward the land to such an extent that the water level rises far beyond the normal tide. When this happens, especially if accompanied by high waves, it can cause great destruction of property and even loss of life. Although, like tsunamis, these *storm waves* or *storm surges* are popularly called *tidal waves*, they are not associated with the tide. About three-fourths of the deaths attributed to hurricanes are caused by *storm surges*.

Real Tidal Waves

The tide producing forces are caused by gravitational attractions and motions of the sun, moon, and earth. The tide these forces finally produce, however, has been greatly changed by such things as internal and bottom friction and presence of continents and irregular bottom topography. The observed tide is in wave form. *Tidal waves* are so very long, however, that we don't readily recognize them as such. When it is high water, we are observing the crest of a tidal wave and when it is low water, the trough. The close proximity of the moon tends to cause observed tidal features to "follow the moon" but to be modified by the sun. Twice each month, when the sun, moon, and earth are lined up for new and full-moon conditions, we have larger than average ranges, called *spring tides*. When they are at right angles for first and third quarter moon conditions, we have smaller than average ranges, called *neap tides*. In certain funnel-shaped estuaries or bays the incoming tide meets the preceding low tide and creates a high-crested, roaring wave called a *tidal bore*.

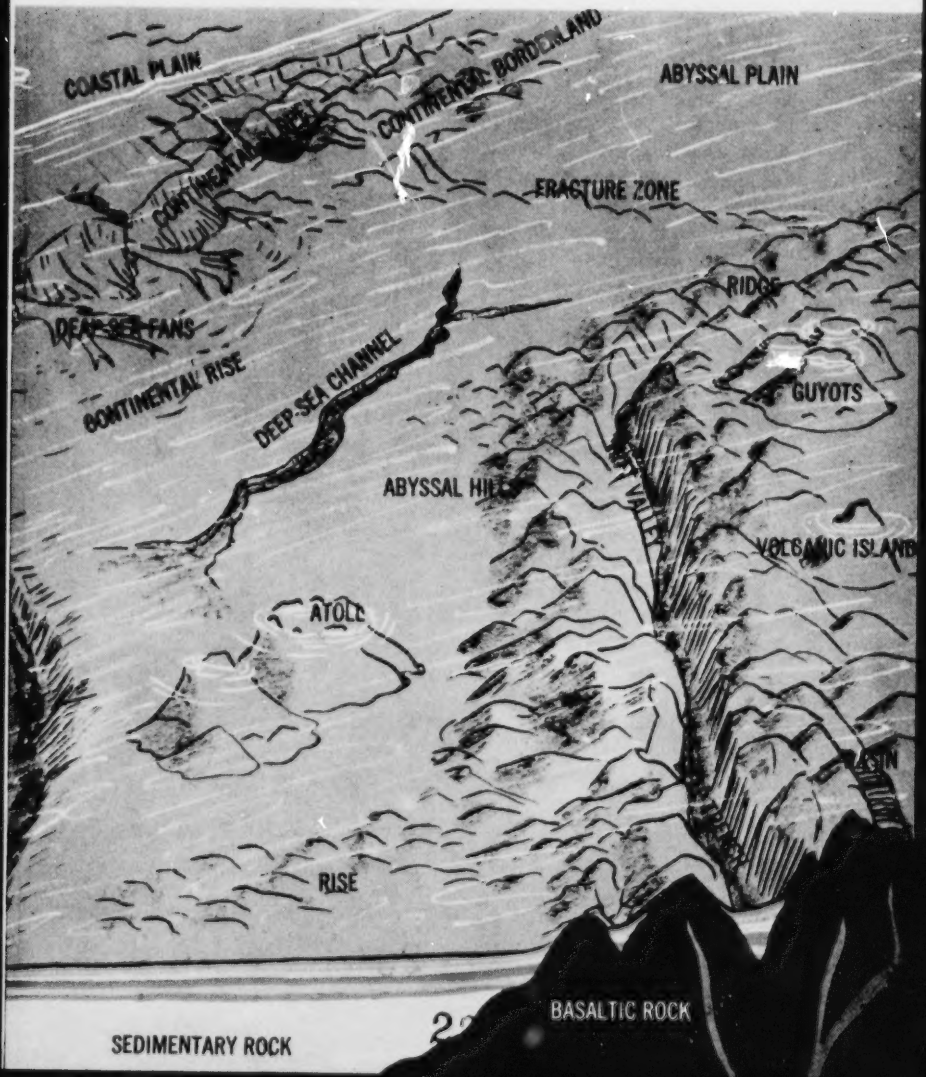
Marine Topography

4. Draw a cross section of underwater topography. Show what is meant by:
a. Continental shelf
b. Continental slope
c. Abyssal plains
Name and put on your drawing the following: seamount, guyot, deep, rift valley, canyon, and trench. Compare the depths in the oceans with the heights of mountains.

The topography of the ocean floor is much more rugged in its mountainous areas than the mountains we know – also the plains of our ocean deeps are as seemingly endless as the Great Plains of the United States.

The greatest mountain range on the sea floor is the *South Pacific ridge,* but the best known is the *Mid-Atlantic ridge.* It is 400 miles wide, 8,000 miles long, and has mountains 28,000 feet high from the floor of the ocean to the top of the peaks.

Most of the topographic features of the sea floor can be compared with features of the land that we are used to seeing.


COASTAL PLAIN
CONTINENTAL SHELF
CONTINENTAL BORDERLAND
ABYSSAL PLAIN
FRACTURE ZONE
RIDGE
DEEP-SEA FANS
CONTINENTAL RISE
DEEP-SEA CHANNEL
GUYOTS
ABYSSAL HILL
VOLCANIC ISLAND
ATOLL
RISE
BASALTIC ROCK
SEDIMENTARY ROCK

The *continental shelf* is much like the Coastal Plains that border many of the ocean areas with the same general relief change and almost flat gradient.

The *continental slopes* have very close relationships with the eroded forelands of mountainous coasts. The *abyssal hills* are closely allied to the foothills surrounding our mountains on land. The *abyssal plains* have many of the features of our own plains in Kansas, Nebraska, Oklahoma, and Texas. The *seamounts* or *guyots* are just individual mountain peaks that are projecting up from a mountain or foothill region. *Canyons* cut across the continental shelves in many places much as our Grand Canyon cuts through the Kaibab Plateau of Arizona.

The major difference in the topography of the sea floor and land topography is that erosion has formed the land into many shapes while the sea floor has been eroded by deep-sea currents and has been covered with deposits and sediments through eons of time.

Therefore, the sea floor is smoother in texture and has steeper canyon faces and cliffs, because erosive factors have not been at work on them. On the whole, very little is known about the topography of the sea bottom as compared to our knowledge of land features.

The great *rift valleys* or mid-ridge *trenches* are seemingly peculiar to the submarine mountain ranges. These are large clefts in the middle of the major ridges of the ocean floor, much in the manner that some of our mountain ranges are broken into pressure ridges and valleys.

The Romanche trench, occupying the center of the Mid-Atlantic ridge along the equator between South America and Africa, is the best known of the rifts and also the largest (400 miles long, 28 miles wide, and 5 miles deep).

HEIGHTS AND DEPTHS OF LAND AND SEA

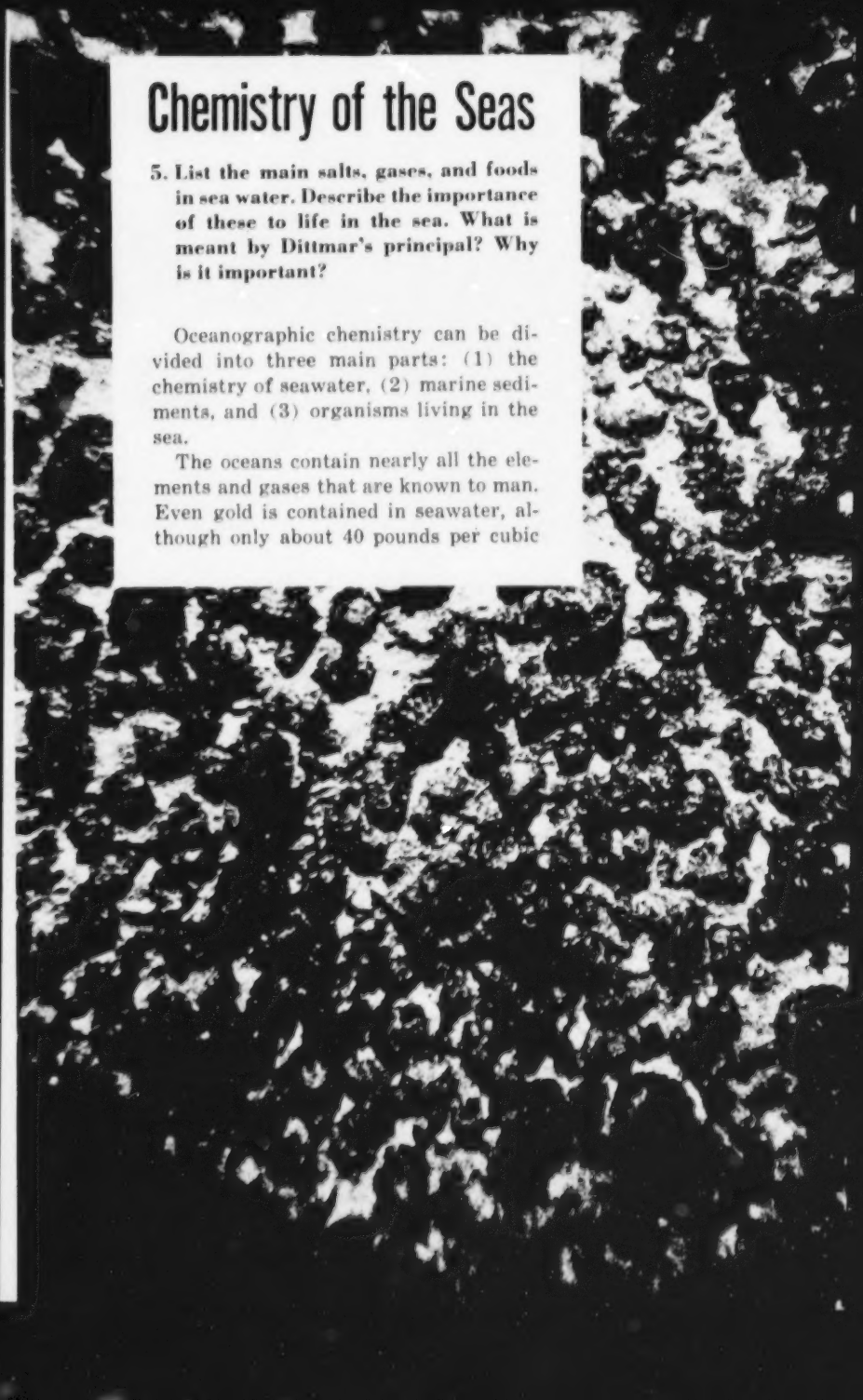
Greatest known height: Mount Everest	29,141 feet above sea level
Average height of the land	2,707 feet above sea level
Average depth of the sea	12,460 feet below sea level
Greatest known depth: Challenger Deep	35,600 feet below sea level

Chemistry of the Seas

5. List the main salts, gases, and foods in sea water. Describe the importance of these to life in the sea. What is meant by Dittmar's principal? Why is it important?

Oceanographic chemistry can be divided into three main parts: (1) the chemistry of seawater, (2) marine sediments, and (3) organisms living in the sea.

The oceans contain nearly all the elements and gases that are known to man. Even gold is contained in seawater, although only about 40 pounds per cubic



mile. The amounts of the most important elements and gases listed below become almost unbelievable when you multiply them by the 330,000,000 cubic miles of seawater in the oceans.

Chemical properties of seawater are determined by analyzing samples of water obtained at various locations and depths. Samples from below the surface are obtained by means of special bottles designed for this purpose. The open bottles are attached at suitable intervals to a wire lowered into the sea.

When they reach the desired depths, a metal ring called a *messenger* is dropped down the wire. When the messenger arrives at the first bottle, it causes the bottle to close, trapping a sample of the water at that depth, and releases a second messenger that travels down the wire to trip the next bottle, etc., until all bottles are closed and can be hauled up.

Each bottle is detached as it comes within reach. Of the various types devised, the *Nansen* bottle is the most widely used.

Dittmar's Principle

A very helpful factor in analyzing samples of seawater is a principle that came out of 9 years' work by Professor William Dittmar, a German chemist. He went on a round-the-world trip in the British ship H.M.S. *Challenger*, in 1872-76, to study the biology of the sea, to collect water samples and bottom samples, and measure water temperatures. He took 77 samples from different locations around the world and analyzed them to find the percentages of dissolved solids (chlorides, sulfates, sodium, calcium, magnesium, and potassium) they contained. His findings confirmed those of two earlier scientists.

The above-mentioned solids make up 99 percent of the dissolved salts in the sea, and the ratio of any one of these solids to the total dissolved solids in any one sample is practically the same in any sample taken in any ocean of the world. In other words, if one of these chemicals makes up 20 percent of the solids in one sample, it will make up 20 percent in any other sample, even though the total amount of solids in each sample might not be the same.

The reason that *Dittmar's principle* is helpful is that when scientists are trying to find the density of water samples on a ship, there are times when the rolling of the vessel makes use of instruments such as hygrometers or weighing devices very difficult. If the oceanographic chemist can find the amount of just one of the solids contained in a sample, he can quickly use Dittmar's principle to figure the proportions of the other solids.

Major Elements of the Sea

Tons per cubic mile of water

Oxygen	4,037,000,000
Hydrogen	509,000,000
Chlorine	89,500,000
Sodium	49,500,000
Magnesium	6,125,000
Sulphur	4,240,000
Calcium	1,880,000
Potassium	1,790,000
Bromine	306,000
Carbon	132,000
Strontium	37,700
Boron	22,600
Silicon	14,130
Fluorine	6,125
Argon	2,825
Nitrogen	2,350

Value to Life in the Sea

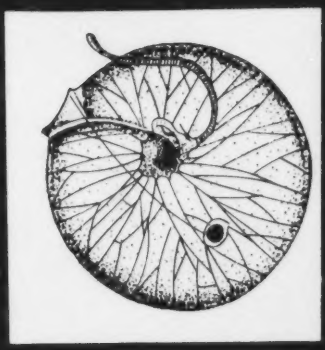
Oxygen, of course, being one of the two elements making up the water itself, is vital to all sea life. The most important elements as far as life in the sea is concerned are silicon, nitrogen, and phosphorus. The way in which living sea organisms use these three elements is not entirely clear, except that it is known that phosphorus is essential in the building of skeletal structure of these organisms and in supplying them with nutrients. These are needed for growth and the completion of the life cycle.

Other Values

As mentioned in Requirement 1, the elements dissolved in the seas have enormous value to man in addition to their contribution to his seafood. Table salt, magnesium, chlorine (also taken from salt), and bromine are the principle chemicals now capable of being processed from seawater.

Because there is a close relationship between dissolved chemicals and bottom sediments, oceanographers often take samples of these sediments, using clamshell or orange-peel devices or coring devices.

Marine Biology

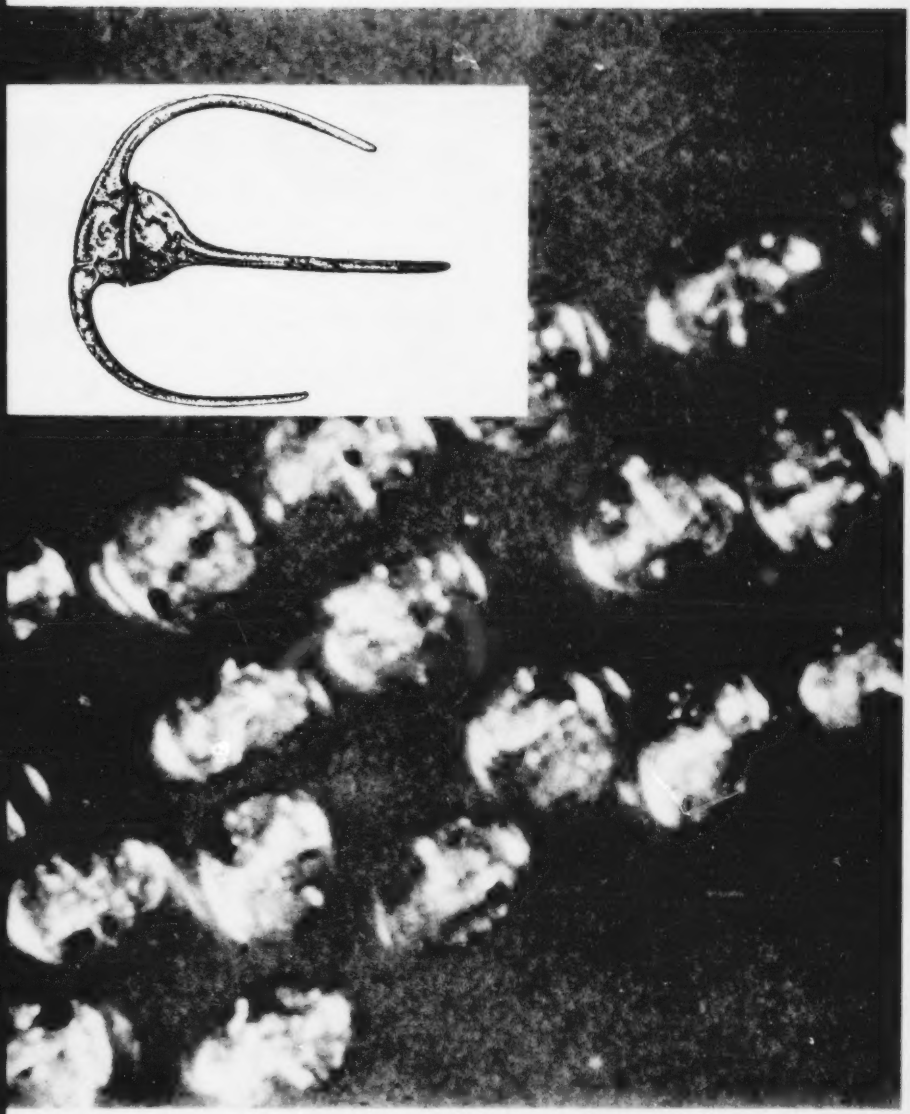


6. Tell the meaning of phytoplankton, zooplankton, nekton, and benthos. Describe the importance of phytoplankton as a main producer of living things. Tell the place and importance of plankton in the food chain.

Seawater has all of the chemical elements needed to sustain plant and animal life. Because of this, and the fact that the oceans contain about 300 times as much space for the existence of life as is available on land and in fresh water, organic material is present in vast quantities.

There are about 150,000 species of life in the ocean. Marine life may be divided into three major groups: (1) *nekton* – strong-swimming animals such as fish, (2) *plankton*–tiny floating plants or feebly swimming or floating animals, and (3) *benthos*–plants and animals living on the bottom, such as seaweed, barnacles, and crabs.

Plankton may be divided into: (a) the *phytoplankton,* consisting of microscopic floating plants; and (b) the *zooplankton,* consisting of feebly swimming or



23

floating animals. Most plankton vary in size from microscopic ones to those a small fraction of an inch in length. Some common types of zooplankton are pictured on the preceding page.

Most organic material in the sea is in the form of plankton, which is carried by the ocean currents, as it does not have sufficient strength to choose its own environment. Either directly or indirectly, nearly all marine life depends upon these organisms.

By means of photosynthesis, a process using sunlight, phytoplankton changes chemical nutrients (potassium, nitrates, phosphates) in the sea into primary food that is used by the zooplankton and to some extent by larger animals. However, most of the larger animals feed upon the zooplankton. The chemical nutrients are replaced by the excretion of animals and bacterial action in the decomposition of dead plants and animals. Thus, a food cycle is continually going on from chemical nutrient to phytoplankton to zooplankton to nekton and benthos to chemical nutrients.

As indicated above, growth of phytoplankton requires both sunlight and a supply of chemical nutrients. Sunlight in sufficient strength to permit photosynthesis penetrates to a maximum depth of about 500 feet or less. This upper layer in which the process occurs is called the *euphotic* zone. Within this zone, photosynthesis is limited primarily by the supply of chemical nutrients. Under favorable conditions, phytoplankton may increase by as much as 300 percent in a single day.

The abundance of marine life is directly related to the supply of phytoplankton. In shallow water, the chemical nutrients on the bottom are stirred up by mo-

tion of the water and carried into the euphotic zone.

This is why an area such as the Grand Bank (near Newfoundland) is a good fishing ground. In polar regions the chemical nutrients are relatively abundant, being brought to the surface by currents as the cold surface water sinks and is replaced by the warmer water from the bottom. In the tropics, on the other hand, the sea is relatively stable, and the chemical nutrients have a tendency to sink below the euphotic zone. Even though the clear, blue water has the deepest euphotic zone, photosynthesis proceeds at a slow rate. For this reason blue is sometimes called the "desert color of the sea."

Ocean currents and marine life are so interrelated that currents can sometimes be traced by their supply of plankton. In general, the oceanic circulation helps sustain marine life by stirring up the chemical nutrients and carrying them or the plankton living from them into regions that have an inadequate supply.

However, the reverse effect can occur. A notable example occurs from time to time off the west coast of South America. At varying intervals averaging about 12 years, a well-developed stream of tropical water having a relatively small supply of chemical nutrients and plankton flows southward, close to the shore. This water replaces the colder water that is rich in chemical nutrients and plankton. The result is a wholesale destruction of fish that cannot obtain a sufficient supply of food.

In some areas the dead fish are washed ashore in such quantities they constitute a serious problem. With the destruction of so many fish, the supply of guano, a fertilizer made from the excrement of birds, also decreases because of the death of large numbers of the waterfowl that depend upon the fish for their food supply. A strong current such as the Gulf Stream annually carries many fish to their deaths by transporting them from their normally warm habitat to areas where they encounter water that is too cold for them to endure.

Almost all the plant life of the ocean falls into the *algae* (al-jee) family, and this single element of food could be an increasing factor in food for our expanding population of the world. Algae come in many forms. The most common is seaweed or kelp—red, green, brown, and blue in color. The Red Sea is colored by a microscopic red algae growth.

Man has lately used a new tool in the exploration of the biologic patterns in the ocean with the advent of the deep-sea camera. By taking pictures of the bottoms of the oceans, a relative picture of the existing life is obtained.

Plankton Collection

7. Do one of the following:

a. Make a plankton net. Tow the net by a dock, wade with it, hold it in a current, or tow it from a rowboat. Do this for about 20 minutes. Save the sample. Examine it under a microscope or high-power glass. Identify the three most common types of plankton in the sample.

The word plankton is derived from the Greek *planktos* – meaning wanderer. All of the drifting and floating life in the pelagic waters (both open and nearshore waters) of the ocean or a lake fall into this category. This group may be further subdivided into zooplankton (animal plankton) and phytoplankton (plant plankton). These organisms may be collected by towing fine-meshed nets through the waters in which they live.

Plankton nets used in most oceanographic research are constructed of silk or nylon bolting (sifting) cloth that is made in several different grades and mesh sizes. The apertures of this material are extremely uniform so it is ideal for accurate collection. However, any fine-mesh cloth such as nylon screening, bobinet, sheer curtain material, cheesecloth, or even a nylon stocking may be utilized to fashion a net suitable for capturing at least a portion of the marine or freshwater plankton.

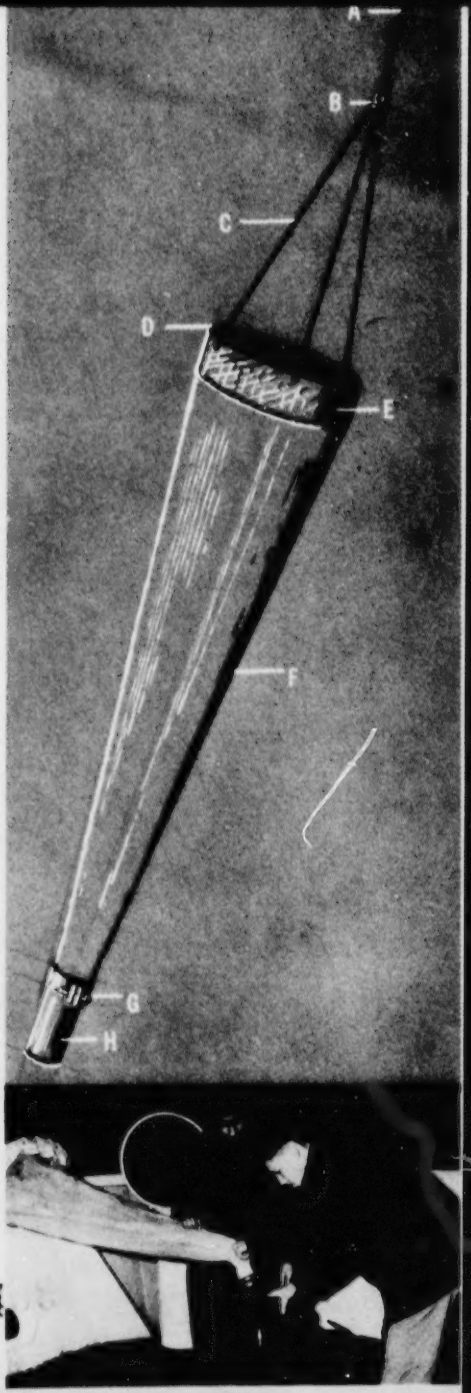
To construct a net one must have netting material (sufficient for a net 3 or 4 feet long), a metal ring (approximately 12-inch diameter), canvas, and a collection bucket (8- to 16-ounce can or jar). To avoid wasting material, a paper pattern should be made first to ascertain the proper net dimensions. Allow enough surplus material for the seams to be folded double and sewed.

Referring to the accompanying diagram: (*f*) A chopped-off cone of netting material is construct-

ed so that the large end has the same diameter as the ring (*d*) and the small end a diameter equal to that of the collection bucket (*h*). Canvas or sailcloth should be used to reinforce the net where it joins the ring (*e*) and the bucket (*g*).

The large opening of the net should be sewed to the ring, and some method devised to tie or clamp the small opening to the bucket. A screw-type, adjustable hose clamp of the proper diameter provides an excellent means of attaching the bucket to the net. The ring is attached to the towline (*a*) by a three-wire bridle (*c*); a swivel (*b*) at this point will help prevent twisting of the bridle lines.

Upon completion of a net tow, all plankton should be rinsed down the sides into the bucket by pouring water through the outer side of the net (not over the top). After concentrating the plankton into the bucket, the bucket is removed and the organisms poured into a container for study.



Coral Reefs and Islands

7b. Make a series of models (clay or plaster and wood) of a volcanic island. Show the growth of an atoll from a fringing reef through a barrier reef. Describe the Darwinian theory of coral reef formation.

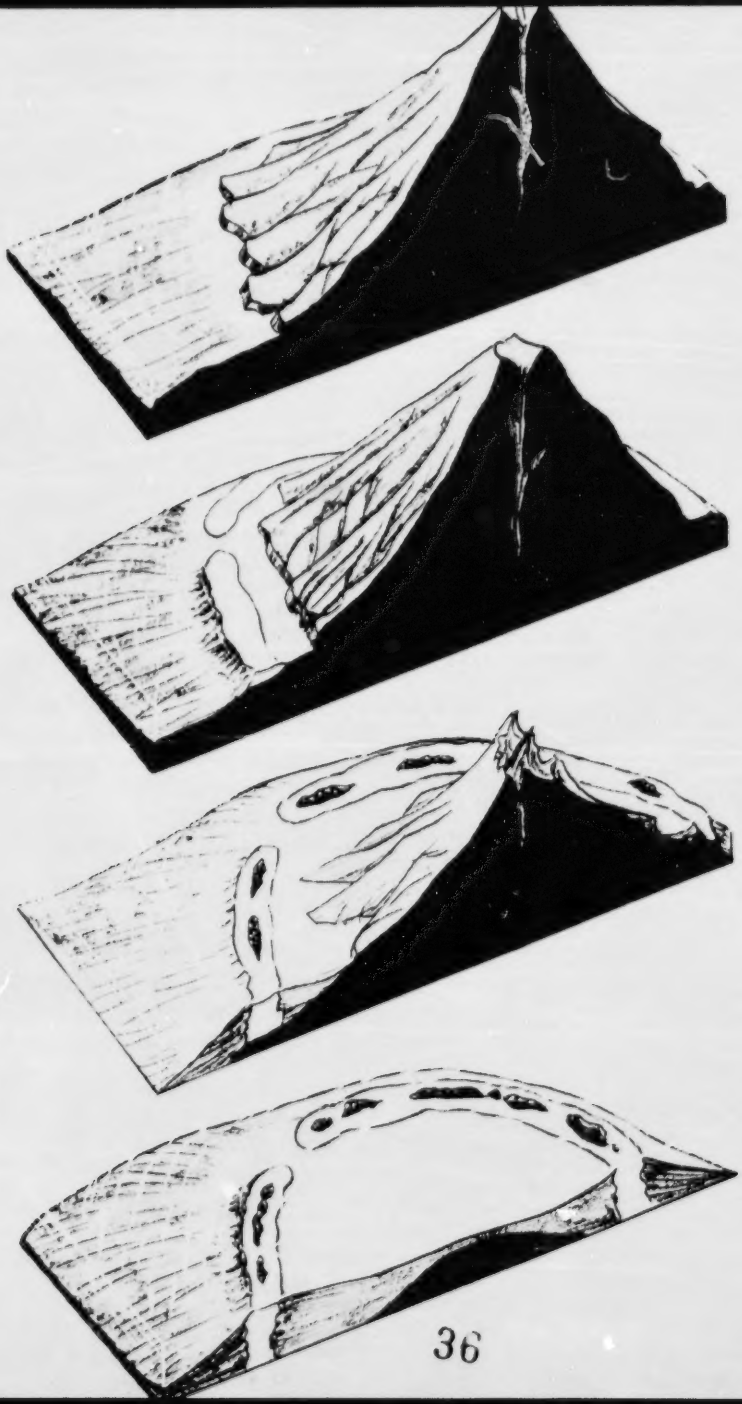
During World War II, our military forces in the Pacific landed on many an island that was like a circular ring, with a blue, peaceful lagoon in the center. These islands were atolls (at-alls), made up of a coral reef topped by soil, coral sand, and vegetation.

Coral reefs are built by lime-secreting organisms, among which polyps (paw-lips), known as corals, and algae are the most abundant. These organisms can exist only in relatively warm, clear water. The algae are thought to form the "cement" that holds the coral formations together. These formations are assumed while the corals are living. They may be rather shapeless masses or may take the form of bushlike, treelike, or antlerlike figures.

When the corals die, they leave their lime (calcium) skeletons behind, and the formations may assume the beautiful white or pastel colors you have seen in giftshops or elsewhere.

Because of wave action, dead coral in a reef may be crushed and broken or ground into coral sand so fine that the original shape is completely lost. In some cases it may be cemented together into a firm "reefrock." Usually, a coral reef has a "lip" on the windward or seaward side where the food supply of the corals was more abundant; and debris may have piled up within the lip to provide soil for vegetation. This growth is the result of seeds, coconuts, or plants washing ashore.

There has been a lot of controversy about how the atolls were formed. Charles Darwin studied them extensively during his Pacific expeditions. He came to the conclusion that they were formed when a volcanic island was ringed by a coral reef and then slowly sank beneath the sea, leaving the circular atoll. The coral probably sank with the island, but so slowly that the reef continued to build up, as shown in the illustrations. Many scientists share Darwin's view.



Water Testing

7c. **Measure the water temperature 1 foot below the surface of a body of water four times daily (8 a.m., 12 n., 4 and 8 p.m.) for 6 straight days. Measure the air temperature. Note the cloud cover and roughness of the water. Show your findings on a graph. Tell how the water temperature changes with air temperature.**

OCEANOGRAPHIC

OBSERVER'S NAME _____

LOCATION				WIND		UNDERWATE TEMP.			
Mo.	Day	Yr.		Dir.	Speed	8 AM	12 N	4 PM	8 P

For this project, the requirements describe exactly what you have to do. We have adapted a real oceanographer's log sheet as a sample for you to use in making your own records. You will want your log large enough to mark down your observations without crowding them.

It is a good idea to cover your log with a piece of plastic to prevent moisture damage.

LOG SHEET

AIR TEMP.				AIR TEMP.				CLOUD COVER				WATER ROUGHNESS			
8	12	4	8	8	12	4	8	8	12	4	8	8	12	4	8
AM	N	PM	PM	AM	N	PM	PM	AM	N	PM	PM	AM	N	PM	PM

Beach Characteristics

7d. Make a model showing the inshore sediment movement by littoral currents, tidal movement, and wave action. Include such things as high and low waterlines, low tide terrace, cusps, beach scarp, and berm. Show how the offshore bars are built up and torn down.

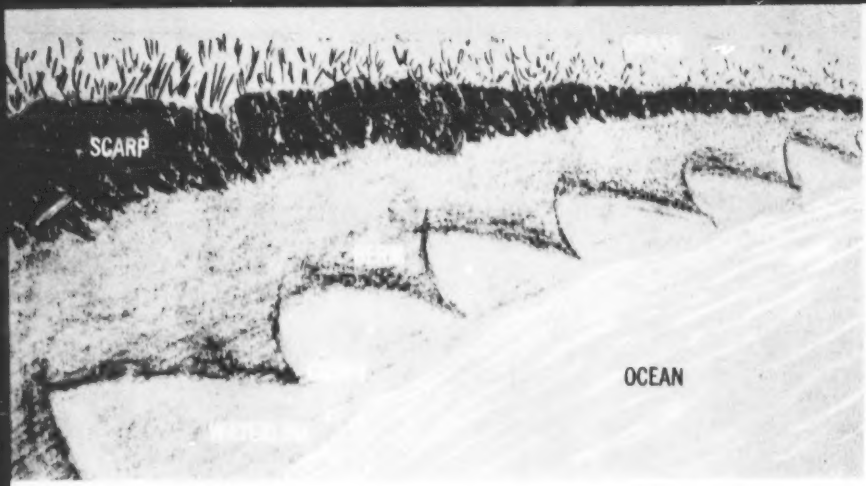
The purpose of this requirement is to give you some understanding as to how waves and currents affect the shoreline. The area we are talking about is between low tide and the highest limit reached by storm waves. The word *littoral* means shore or pertaining to the shore.

If you have visited a beach for a swim, you have probably had to go down a rather abrupt bank or slope to get there. This downgrade or sudden drop, as the case may be, is called a *beach scarp* (which comes from the same base word as escarpment). In some cases it is actually a cliff, requiring a stairway or steep path for the bathers. The scarp is caused by the water undercutting the earth or, in the case of sand dunes, piling up the sand with the help of the wind.

When you were on the beach, you probably noticed a sort of ridge running along about where the average waves can reach. This is the *berm*, and you will often find it productive if you are looking for shells or just doing a little beachcombing. By wave action, it is built up of

sand or coarser sediments. There may be more than one berm.

Cusps are a beach characteristic not often noticed by bathers. The word means "points," and you have most often heard it used in connection with teeth (a bicuspid is a tooth with two points). And cusps can give a general toothlike appearance to a beach if they are prominent enough. They are caused when waves pile over the top of the berm and run back along restricted lanes, making depressions and leaving ridges in between. The ridges are shaped into points by the waves. These points are much more common when the tide range is small and



are removed if they are submerged for a few hours.

When you wade into the ocean at a beach, you will often notice a sort of trough or depression that runs along about the same distance from the water's edge. This is the *plunge line* caused by the scouring of the breakers where they most frequently plunge into the shallows. Beyond the plunge line there is likely to be a very shallow area where you may wade ankle deep at low tide for quite a distance before deeper water allows you to swim. This is a *wave-cut terrace*, and it is sometimes called a *low tide terrace*, because it is wave action at low tide that levels it. As the drawing shows, bedrock may be close to the surface or visible.

Waves approaching a shore are very seldom perfectly perpendicular to it. They most often come in at an angle. The water, therefore, may not go straight up the beach and straight back. It usually goes up at an angle, makes a parabolic curve, and slides back at a different point than it came in. Any sediment that it carries, if not left on the beach, also goes back at a different point. As successive waves again bring the sediment in, it moves farther and farther along the shore. This movement is called *beach drift*.

Shore Currents

There are several kinds of currents set up along the shore by wind and *wave action*. There are the longshore currents caused when waves approach the shore at an angle and rip currents where water piles up against a

shore and reacts seaward again as shown in the illustration. If you have swum at a fairly steep beach, you may have felt a rip current pulling your legs toward the sea. Where these currents are strong, they are hazardous for swimmers. Other currents are affected by rocks, underwater obstacles, narrow channels, etc.

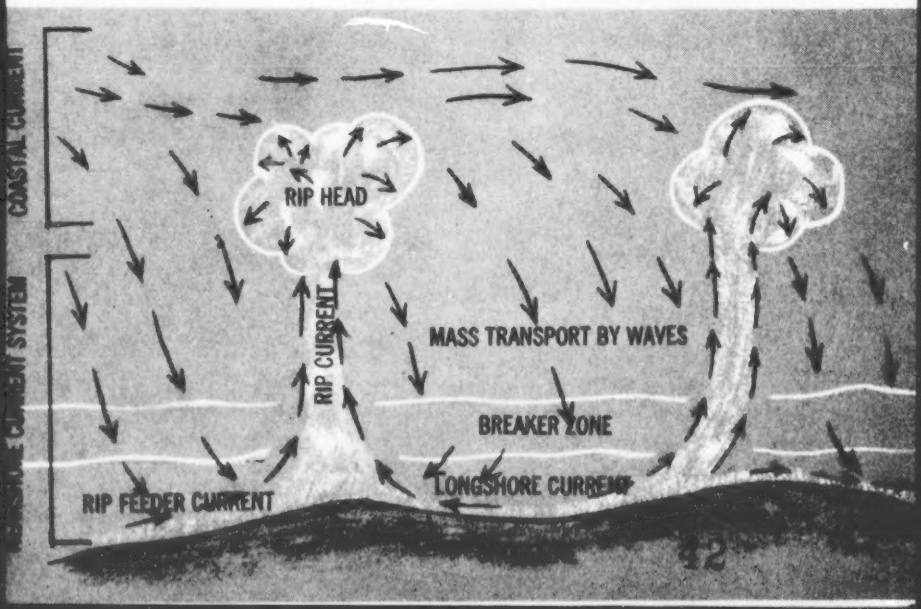
Sandbars

Where shore currents flow in one location for any length of time, they are likely to deposit sediment, building an underwater bar. Along a beach, these are usually sandbars; and they may be perpendicular to the shore, horizontal or otherwise, depending on the direction of the current. Once they start to form, they help to slow the current and cause more sediment to settle, as a snowdrift catches more snow.

Sandbar formation can be a real problem along a beach, especially if the beach is eroding. Jetties and groins are often built to control the currents and their sediment deposits and are used in some cases to build up an eroding shoreline.

Underwater bars near shores exposed to varying winds and waves will change location, sometimes in a surprisingly short time. Any change in the current that has formed a bar is likely to change the bar's formation or even remove it altogether.

After a sandbar is built up above the water surface, it is called a *spit* or a *hook* if it is sufficiently crescent shaped.

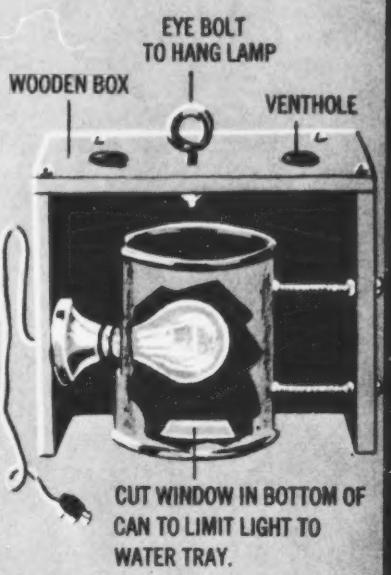


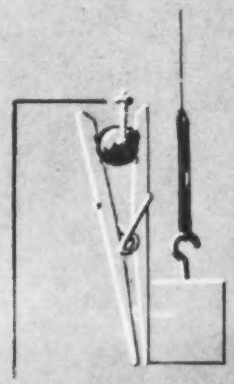
Wave Testing

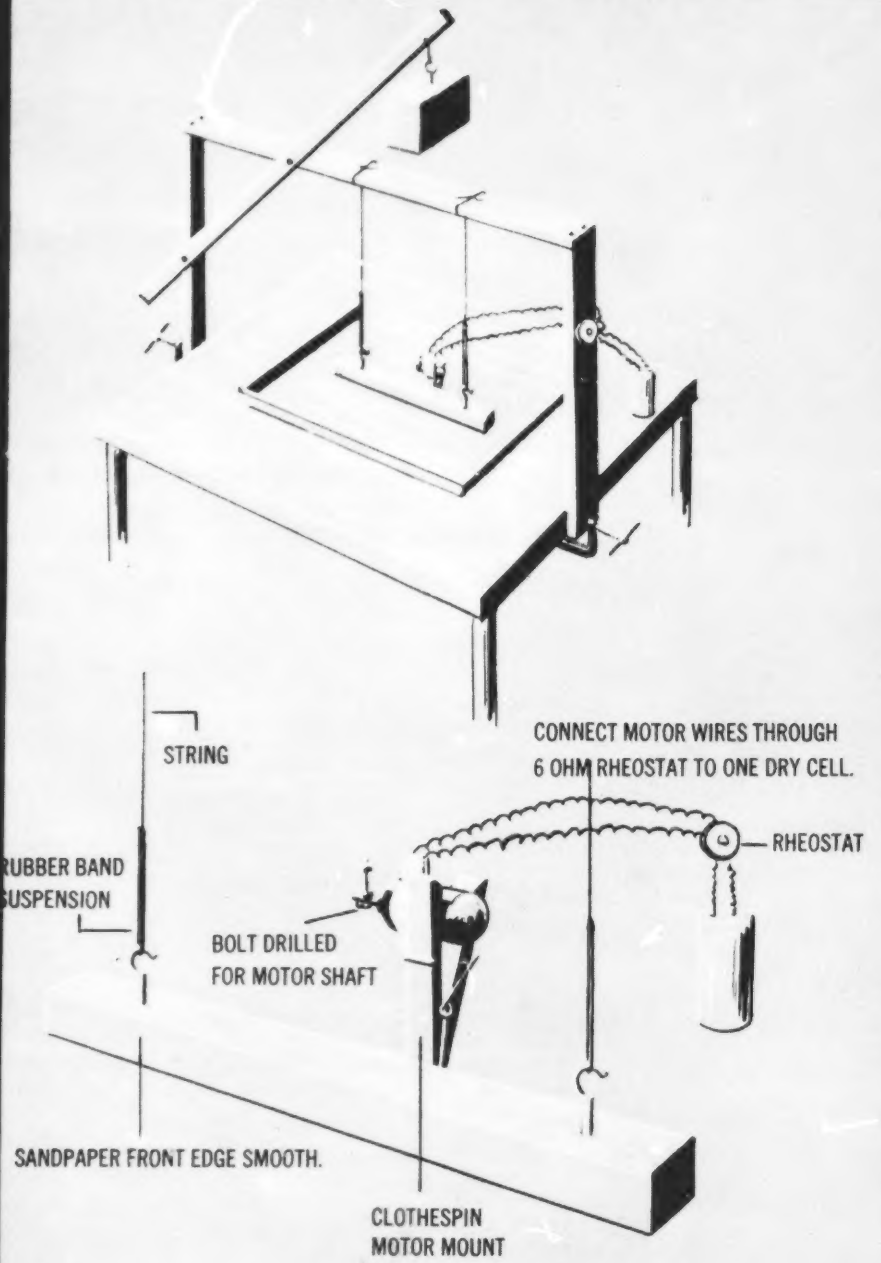
7e. Make a wave generator. Show reflection and refraction of waves. Show how groins, jetties, and breakwaters affect these patterns.

A wave generator is a device that is used to produce waves in a tank or other water container so studies can be made of wave action. For your project you can make a very simple one that will not be expensive or hard to put together.

Use a shallow tray or pan for your water container. It should be deep enough to hold at least an inch of water.


PAINT ALL INSIDE SURFACES OF CAN AND BOX BLACK.
EYE BOLT TO HANG LAMP
WOODEN BOX
VENTHOLE
CUT WINDOW IN BOTTOM OF CAN TO LIMIT LIGHT TO WATER TRAY.




STRING
CONNECT MOTOR WIRES THROUGH
6 OHM RHEOSTAT TO ONE DRY CELL.
RHEOSTAT
RUBBER BAND
SUSPENSION
BOLT DRILLED
FOR MOTOR SHAFT
SANDPAPER FRONT EDGE SMOOTH.
CLOTHESPIN
MOTOR MOUNT

Materials Needed

For the generator itself you will need the following parts:

1 piece of smooth wood, slightly shorter than the width of the pan (1- x 1-inch stock will do). Make sure it is smooth by sanding if necessary.

2 brass screw hooks

2 rubber bands, at least 4 inches long before stretching

1 pinch-type clothespin

1 ¼- x 1-inch bolt and 2 nuts to fit it

1 miniature DC motor such as is used to drive model boats, etc. Most hobbyshops have these.

1 rheostat to control speed of motor (hobbyshop)—and flashlight batteries or dry cell to operate motor

1 old card table to hold generator

Building the Generator

Screw the hooks into the wave bar about ½ inch from the ends. Drill a hole in one handle of the clothespin and screw it to the side of the bar, a little off center.

Drill a hole in the bolt about ¼ inch from the head, just large enough for the motor shaft. Screw one nut on the bolt clear up to the head. Then insert the motor shaft in the small hole and tighten the nut to hold the bolt firmly on the shaft. Put the other nut on the bolt above the shaft, but don't tighten it. It is used to adjust the amount of vibration you want.

Wire the motor to the battery by way of the rheostat and clamp it to your bar with the clothespin.

Now sling your generator above the water tray by strings attached to the rubber bands, so the bar just touches the water in the tray and is flat with the water surface. Start your generator, and adjust the free nut on the ¼-inch bolt so you get a vibration of not more than 1/16 of an inch. Too much vibration will spoil the wave patterns. You can adjust the wave lengths by increasing or decreasing your motor speed. If you run the motor too fast, the waves will be too close together. Too slow will give the opposite effect.

In order to see the waves and

their effects, shine a bright light on the water so it will be reflected on a wall or large white piece of paper. The best type of light would be a homemade projector, as shown, or a slide projector if you happen to have one.

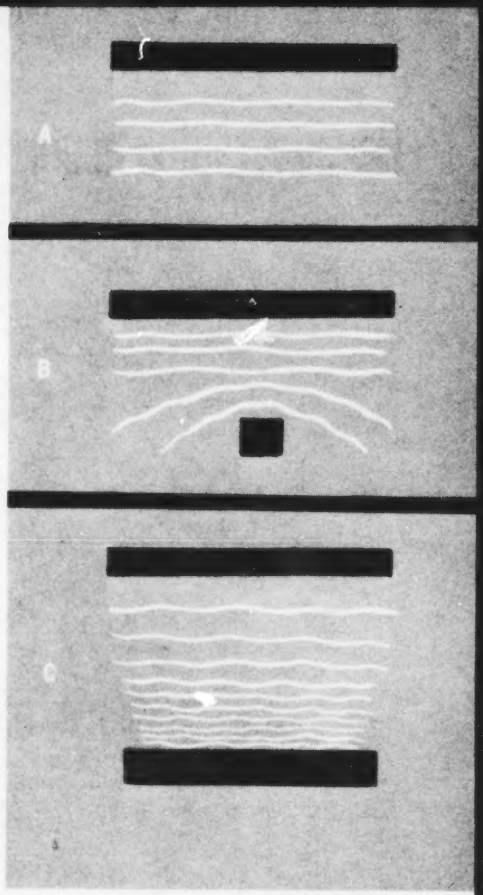
By placing small rectangles of glass or plastic in the opposite end of the pan from the generator, you can represent a breakwater, a smooth beach, a jetty, or a groin. Then you can demonstrate how waves are reflected (turned back without bending) or refracted (deflected).

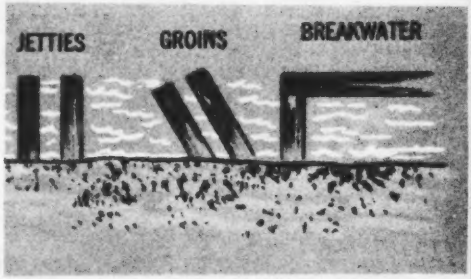
When there is no obstruction to the waves, you will get a pattern about like (a).

Refracted waves will look like (b).

Reflected waves will look like (c).

Groins and *jetties* are manmade structures, usually of stone or concrete, jutting out from the shoreline to control erosion or sediment deposits caused by inshore currents. *Groins* are placed at an angle to the shoreline and *jetties*, perpendicular to the shoreline. *Breakwaters* are concrete or stone structures designed to break the action of waves on the shore or to provide a calm harbor for shipping and boating.





Oceanography Reporting

8. Do one of the following:

a. Write a 500-word report on any good book about oceanography. (Before reading have your counselor approve it.)

b. Visit one of the following and write a 500-word report about your visit: (1) an oceanographic research ship or (2) an oceanographic institute.

c. Explain to your troop in a 5-minute prepared speech "Why Oceanography Is Important" or "Jobs in Oceanography." (Before making it, show your speech outline to your counselor.)

This requirement gives you an opportunity to display some of the things you've learned about oceanography. The ability to write or to talk about a subject often helps to fix the knowledge in your mind. It also teaches you what every scientist should be able to do, and that is to communicate the results of his research to other people.

For the book report in (*a*), you can select any book in the bibliography in the back of this pamphlet or any other book recommended by your counselor. If you are so fortunate as to visit the ship or research institute in (*b*), you can show good reporting by using the right language and correct information you've learned in the pamphlet. For (*c*) you can refer to pamphlet material or, in the case of career information, you can use books such as *Pioneer Oceanographer: Alexander Agassiz,* information from school guidance pamphlets, or government pamphlets such as *Career for You,* U.S. Oceanographic Office, Washington, D.C. 20390.

BOOKS ABOUT OCEANOGRAPHY

Recommended by the American Library Association's Advisory Committee to Scouting

Beneath Land and Sea, Aylesa Forsee, 1962

An exciting presentation of undersea canyons, rivers, and mountains; subterranean secrets and treasures.

Life in the Deep, Maurice Burton, 1958

Ways and means of obtaining the riches found in the sea are described in this book.

Oceans of the World, Boris Arnov, 1962

Mr. Arnov describes in a narrative style the history, geography, and ocean animal life.

Pioneer Oceanographer: Alexander Agassiz, Beryl Williams and Samuel Epstein, 1963. Boys who might be interested in becoming oceanographers will enjoy this fascinating book.

The Sea Around Us, Rachel Carson, 1958

This is a readable book about the sea and sea life. A good "first" book to read for this badge.

A Biography of the Sea, R. Carrington

All About the Sea, Ferdinand C. Lane

All About Undersea Exploration, Ruth Brindze

Assault on the Unknown, W. Sullivan

Basic Geology, E. C. Dapples

Beaches and Coasts, C. A. M. King

Edge of the Sea, Rachel Carson

Exploring Under the Sea, Sam Hinton

Frontiers of the Sea, R. D. Cowen

The Earth Beneath the Sea, F. P. Shepard

Ocean Harvest, Helen W. Vogel

Surveyor of the Sea, Bern Anderson

Ten Miles High, Two Miles Deep, Alan Hanour

The Open Sea, Vol. 1, *The World of Plankton*, Vol. 2, A. C. Hardy

The Global Sea, Harris B. Steward, Jr.

The Sea, Nature Library, *Life* Magazine

The Story of the Oceans, J. S. Douglas

The Underwater World, John Tossus

The World We Live In, *Life* Magazine

Under the Sea Wind, Rachel Carson

HYDROGRAPHIC OFFICE PUBLICATIONS ON OCEANOGRAPHY

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GLOSSARY OF SUBMARINE TERMS

ABYSSAL HILLS
An area of low-lying hills or low-ranging seamounts, usually occupying the rough-topography area of a deep or basin

ABYSSAL PLAINS
An area of fairly smooth topography occupying the deeper areas of the oceans with relatively small elevation changes

APRON
A relatively small platform formed on only one side of an island group

BANK
A more or less flat-topped elevation near the surface but deep enough for surface navigation, greater than 11 fathoms

BASIN
A large depression with more or less oval or circular form

CANYON
A steep-walled fissure cutting across the shelf and penetrating the slope

CONTINENTAL SHELF
A wide area surrounding a continent extending from the low waterline out to the depth where a marked or steep descent to the greater depth occurs usually about the 120-fathom line. Sometimes the shelf is fairly narrow along submergent coasts.

CONTINENTAL SLOPE
The slope from the edge of the continental shelf down to the deep-water area

CRESCENT
An arced line of relatively high seamounts and peaks

DEEP
An area in the ocean of greater depth than 3,000 fathoms

DEPOSITIONAL TERRACE
An area of fairly smooth topography usually found in conjunction with very large estuaries and usually delta shaped

DEPRESSION
Any area of low elevation surrounded by higher elevations; usually a small basinlike structure

EUPHOTIC ZONE
That part of a body of water that is suitable for abundant production of living organisms, due to the effects of photosynthesis caused by sunlight. The euphotic zone extends from the surface downward to the limit of effective sunlight.

GUYOT
A flat-topped seamount, probably the top of an eroded volcano or island platform

INSULAR SLOPE
A slope bordering an island

MIDOCEAN CANYON
A steep-walled, flat-bottomed depression cutting through or across any of the flat area in deep water

PEDESTAL
A relatively flat-topped plateau, equivalent to a mesa in normal topography, generally at a very shallow depth (20 to 50 fathoms)

PLATEAU
The broad top of a rise

PLATFORM
A large, high plateau in the ocean bed usually surmounted by an island group

REEF
A rocky or coral elevation generally elongated that is a danger to surface navigation

RIDGE
A long and narrow elevation with steep sides and usually surmounted by seamounts and peaks and cut by canyons and trenches

RIFT VALLEY
A valley notching the top of a ridge usually of fairly large dimensions and sometimes occurring in number across the top of a ridge

RISE
A long and broad elevation with a gentle slope

SCARP ZONE
An area of very rough topography with high canyon walls and cliffs on one side and seamounts or foothills rising on the other side; usually found in conjunction with the lower edge of the platforms and aprons of island groups

SEAMOUNT
An isolated mountainlike structure rising from the sea bottom, sometimes the highest mount in a foothill region or the highest mount in a ridge or welt

SHOAL
A detached elevation with such depths that it is a danger to surface navigation (not composed of rock or coral)

SILL
An elevation separating two basins

SILL DEPTH
The lowest elevation at which there is horizontal communication between basins

STEP
A relatively smooth area atop a canyon wall, usually surmounted by a second canyon wall or foothill

TRENCH
A long, narrow depression with steep sides

TRENCH PLAIN
An abyssal plain lying inside a trench

TROUGH
A long, broad depression with gently sloping sides

VALLEY
A gently sloping walled fissure cutting across the shelf and penetrating the slope

WELT
A large, elongated elevation equivalent to a mountain range in land topography

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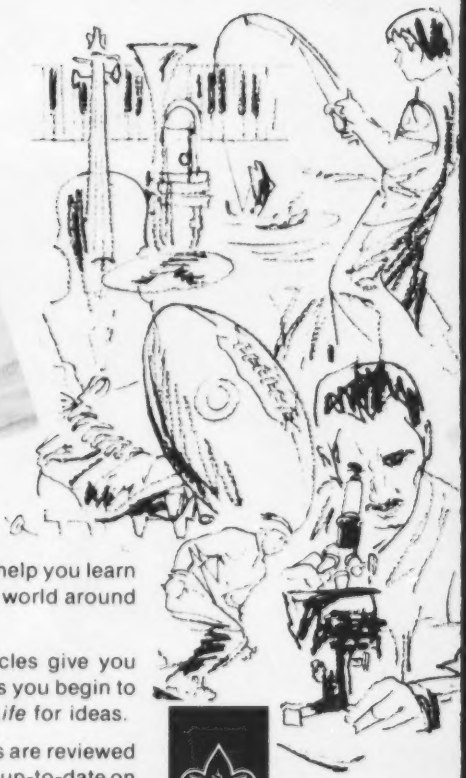

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